Executive Summary: Channel Design

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As part of the process outlined in Washington's *Statewide Strategy to Recover Salmon: Extinction is Not an Option* the Washington Departments of Fish and Wildlife, Ecology, and Transportation were charged to develop Aquatic Habitat Guidelines employing an integrated approach to marine, freshwater, and riparian habitat protection and restoration. Guidelines will be issued, as funding allows, in a series of manuals addressing many aspects of aquatic and riparian habitat protection and restoration.

This document is one of a series of white papers developed to provide a scientific and technical basis for developing Aquatic Habitat Guidelines. The white papers address the current understanding of impacts of development and land management activities on aquatic habitat, and potential mitigation for these impacts.

The scope of work for each white paper requested a "comprehensive but not exhaustive" review of the peer-reviewed scientific literature, symposia literature, and technical (gray) literature, with an emphasis on the peer-reviewed literature. The reader of this report can therefore expect a broad review of the literature which is current through late 2000. Several of the white papers also contain similar elements including the following sections: overview of the guidelines project, overview of the subject white paper, assessment of the state of knowledge, summary of existing guidance, recommendations for future guidance documents, glossary of technical terms, and bibliography.

The channel design white paper summarizes the state of current knowledge and technology pertaining to channel design methods and practices. It is based on a thorough review of published literature regarding the science of channel design. It is intended to be an overview of approaches and techniques used for channel design, and the ecological and habitat issues associated with these methods. The white paper is divided into two basic sections: one which addresses the fundamental aspects of stream channel form and process that provide a basis for channel design, and another that describes aspects of applied stream channel design methodology.

Natural stream and river systems continuously exhibit processes of adjustment that include channel migration, channel evolution, hydrologic changes, and sediment and debris alteration. An understanding of the fundamental fluvial processes is important to allow, maintain or provide for natural geomorphic processes in channel design. Streams and streamflow are defined by climatic parameters such as precipitation and temperature, as well as by physical factors such as topography, soils, geology, vegetation, and land use. Climatic and physical variability results in variability of channel form and processes. As described in the first section, it is this variability that sustains the geomorphic and ecological health and creates habitat diversity in the fluvial system. Furthermore, changes in land use impact the hydrology and sediment transport characteristics of river channels, which influence channel morphology. In the Pacific Northwest,

urbanization and deforestation are two of the most common land use changes. When land use changes are known, or changes are expected, hydrologic changes can be predicted and incorporated into management decisions that include channel design.

Stream classification systems have been developed and are commonly used to characterize the physical components of stream segments and to infer other attributes. Classification systems can be a very useful tool for communicating an infinite range of changes in channel form, but they have become controversial in terms of their application to channel design given the potential limits in the systems themselves and the misapplications of the systems. The opportunities and limitations of the use of stream classification systems for both description and design are discussed in this paper.

Stream channel design is a relatively new science that is being implemented with increasing regularity by a number of varying disciplines including biologists, ecologists, geomorphologists and engineers. Objectives typically include habitat enhancement, channel restoration, channel stabilization, or various combinations. This paper addresses the establishment of design criteria as an important first step in design to facilitate mutual understanding of expectations of the property owner, project sponsor, designer, and regulatory agencies. Design criteria are expressed in relation to design discharges. A project may have a number of design discharges pertaining to different levels of conveyance and performance issues of channel banks, channel bed, and habitat structures. Varying levels of risk tolerance associated with design discharge are often governed by the physical conditions of the project, ranging from a completely natural setting to a confined urban setting.

Hydraulic analysis provides the foundation of river restoration design and is the basis for further analyses such as sediment transport and conveyance. The use of one-dimensional hydraulic models is widely accepted and used for a range of applications such as flood stage analysis, tractive force analysis, and for inputs to sediment transport analysis. Sediment transport analysis is one of the most important components in channel design but is far less often evaluated. Sediment transport analysis focuses on channel stability by evaluating the conditions of equilibrium where the amount of sediment coming in is equal to the amount of sediment going out. Various sediment transport models exist, but their applicability as a design tool is largely dependent on the particle sizes they were calibrated with. Sediment transport is currently an important component of fluvial geomorphic and hydraulic research, and should eventually become a routine part of channel design.

Three common approaches to channel design analysis are described in the white paper; these include: the reference reach approach, the empirical approach, and the analytical approach. The first two approaches are the simplest, but do have certain limitations, such as: 1) the assumption that a design reach is under regime, or is stable; and 2) applicability to the conditions under which specific relationships were calibrated. An analytical approach is desirable as channel conditions are quantified through analysis rather than assumed; however, it is not regularly applied due to the level of data and time needed, and the level of experience in the designer.

Within the context of this white paper, design issues and ecological considerations for measures to increase habitat complexity and channel stability are described. These have been sorted into four general categories of stream channel modifications: 1) channel bed and longitudinal profile; 2) channel planform; 3) channel cross-section; and 4) creation or adjustment of high flow channels. The success and failure of various techniques reported in the literature are described within the framework of these categories. Channel design within the urban environment is also discussed, with particular attention to design approach within the constraints of the altered channel form and function.

Lastly, an outline is proposed for the development of a channel design guidance document.